

The Dynamics of Interchange Reconnection

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Interchange Reconnection is the fundamental mechanism by which open and closed magnetic fields interact in the Sun's corona. This process is central to all theories for how the corona couples to the solar wind, including both the quasi-steady and the diffusion models. It is also believed to produce the polar jets and plumes that are observed by Hinode and SDO as ubiquitous features of coronal holes, and has been proposed by Parker and others as the basic process for solar wind heating and acceleration.

We performed a study of interchange reconnection in the magnetic topology most relevant for the solar corona, the field of a small subsurface dipole in a polar coronal hole (Edmondson et al, ApJ, 714, 517, 2010). Figure 1 shows the resulting topology, which consists of the well-known pair of spine lines and separatrix fan surface, intersecting at a 3D null point. We then drove the system by applying an incompressible photospheric flow that moved the closed bipolar region toward the coronal hole boundary. The motions produced stress at the null and separatrix, resulting in a current sheet there and eventually to interchange reconnection, Figure 2.

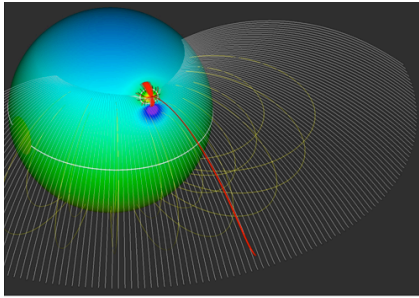


Figure 1. Magnetic topology of a small near-surface dipole inside the northern polar coronal hole. Colored contours show magnitude of radial field at photosphere, the two white curves indicate polarity inversion lines (radial field vanishes). The yellow field lines above the surface correspond to streamer belt closed flux and the white field lines to the open, coronal hole flux that maps to the source surface.

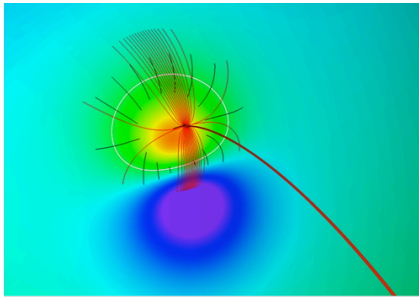


Figure 2. Interchange reconnection between the closed field of an embedded bipole and background flux. Top left $t = 0$ s; initial configuration showing white open field lines, and orange closed. The black contour lines indicate the magnetic null point. Right $t = 5,880$ s; current sheet formation. The filled color contours indicate current magnitude. Bottom left $t = 7,480$ s; global topology change of external spine. Right $t = 10,000$ s; final configuration showing that the bipole is wholly inside the closed field.

Our studies led to two major conclusions. First, interchange reconnection driven by large-scale motions applied at the photosphere leads to a smooth non-bursty dynamics, which can account for polar plumes. For explosive events such as jets the reconnection must also involve some quasi-ideal energy release, as in our twist model (Pariat et al, ApJ 714, 1762, 2010). Second, the interchange reconnection maintains a well-defined magnetic topology with clearly separated open and closed regions, in direct disagreement with the diffusion-type models for the coronal-heliospheric field. The simulation results support instead our recent S-Web theory for the origins of the slow wind (Antiochos et al, ApJ, in press, 2010).